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Purpose/Objective: This study evaluated a number of commercial auto-segmentation algorithms and quantified their accuracy compared to inter-observer variability to identify their suitability for clinical use without or with minimal manual intervention.

Materials and Methods: 12 head-and-neck (H&N) and 12 prostate patient CT scans, delineated by experienced consultants for clinical use, were selected as gold-standard cases. Outlines for brain, brainstem, spinal cord, mandible, and parotids in H&N cases and bladder, prostate, rectum, seminal vesicles and femoral heads in prostate cases were automatically generated by several algorithms:

- OnQ rts atlas-based segmentation (ABS); with user defined atlases
- RayStation ABS; with user defined atlases
- RayStation model-based segmentation (MBS)
- Pinnacle smart probabilistic image contouring engine (SPICE)
- MultiPlan AutoSegment semi-automatic MBS; requires user to manually define initialisation points (pelvis only)

The datasets were also manually re-contoured by two additional observers (consultant, registrars or specialist radiographer) to quantify inter-observer variation. All contours were quantitatively compared against the reference contours using the mean distance to conformity (MDC) and DICE similarity coefficient (DSC):

$$DSC = \frac{2|V_A \cap V_R|}{|V_A| + |V_R|}$$

where V_A is the evaluated volume and V_R the reference volume. DSC can take values between 0 and 1 with 1 revealing perfect overlap while 0 no overlap between the two contours. MDC is defined as the average distance that all outlying points in V_A must be moved to achieve perfect conformity with V_R and is measured in units of distance (i.e. mm).

Results: Figure 1 shows representative examples of slice-wise MDC uncertainties observed in the H&N region. The evaluated algorithms performed better in structures with bony anatomy or high contrast to surrounding tissue (e.g. median MDC range of 1.4-1.7mm for spinal cord) and less well in soft tissue and low contrast regions (e.g. median MDC range of 2.8-3.5mm for parotids), with substantial errors occasionally observed (e.g. lowest decile MDC range of 6.0-14.6mm for parotids). In the male pelvis region MBS algorithms performed better than ABS algorithms as demonstrated by the mean DSC results in Table 1. Although some algorithms performed comparably with inter-observer variability in 90% of the examined CT slices, in both H&N and prostate anatomies, the input of an expert observer is still generally warranted. It should be noted that within the lowest decile (not shown in Fig. 1) all algorithms deviated substantially beyond the range of inter-observer variability.

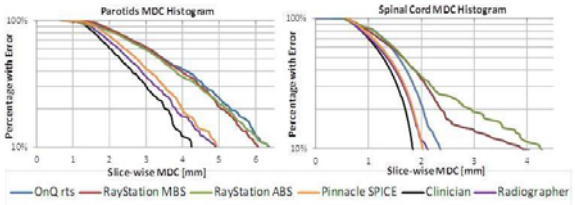

Fig. 1. Slice-wise mean distance to conformity (MDC) histograms across the 12 head-and-neck cancer test cases for parotids and spinal cord manual- and auto-segmentation as compared to the gold-standard.

Table 1. Mean DICE similarity coefficients across the 12 prostate cancer test cases for bladder, prostate and rectum manual- and auto-segmentation as compared to the gold-standard.

	Registrar 1	Registrar 2	Pinnacle SPICE	MultiPlan MBS	RaySation MBS	RayStation ABS	OnQ rts ABS
Bladder	0.96	0.96	0.93	0.91	0.90	0.62	0.88
Prostate	0.85	0.86	0.79	0.78	0.77	0.60	0.62
Rectum	0.70	0.75	0.71	0.68	0.64	0.53	0.60

Conclusions: The performance of the tested algorithms was inferior to inter-observer variability in both H&N and prostate anatomies, and would need evaluation and corrections before contours could be used clinically. Certain algorithms, however, exposed comparable uncertainties to inter-observer variability and would only require minor manual corrections.

PO-0932

Use of a custom abdominal corset to reduce pancreatic tumor motion during stereotactic radiotherapy

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Purpose/Objective: Stereotactic radiotherapy requires exact knowledge of the tumor position to achieve a high dose delivery to the treatment volume. Pancreatic tumors show a large breathing induced motion up to 3 cm or more. Different motion management strategies are available in order to obtain smaller treatment margins, for example abdominal compression or gated radiotherapy. In this study, we explore the effect of a custom abdominal corset on pancreatic tumor motion with cine MRI.

Materials and Methods: Ten patients with unresectable pancreatic cancer scheduled for stereotactic radiotherapy were included in this study. For all patients, a custom abdominal corset was manufactured (Neofrakt®, **Spronken Orthopedie NV**, Genk, Belgium. Figure 1A). All patients were scanned twice on a 1.5T scanner (Achieva, Philips, Best, The Netherlands); once without the corset, and once with the corset in place. The corset was tightened to the patient in a way that it was tight but still reasonable comfortable. Each scan session included one sagittal and one coronal cine MRI scan with a T2/T1 weighted contrast (bSSFP) localised through the center of the tumor (Figure 1B). Image parameters: frame rate = 2 Hz, slice thickness = 7 mm, scan duration = 1 minute. Tumor tracking was performed with a Minimum Output Sum of Squared Error (MOSSE) adaptive correlation filter, which enables real-time tracking of a moving object. Motion in each direction was reported as the

100% and 95% motion, where 100% is the peak-to-peak motion. The 95% is defined as the bandwidth that includes 95% of the data points but excludes the 5th percentile most extreme data points.

Results: The two MRI scans were obtained with a mean interval of 16 days (range 0-37 days). All patients tolerated the corset well during MRI scanning and radiotherapy. Motion characteristics are described in Table 1. Peak-to-peak motion without corset in craniocaudal direction was on average 11.3 mm, with a maximum amplitude of 22.1 mm. With the application of the corset, the average 100% craniocaudal motion was 7.3 mm (maximum amplitude 13.4 mm). The largest decrease in 100% motion was seen in craniocaudal direction, with an average reduction of 4.1 mm. In lateral direction, a decrease in 100% motion of 0.4 mm was observed. In anteroposterior direction, no motion reduction was seen. The largest motion reduction achieved in one patient was a 100% motion of 22.1 mm without corset; with the corset this was 4.9 mm. A typical example of tumor motion pattern with and without corset is shown in Figure 1C.

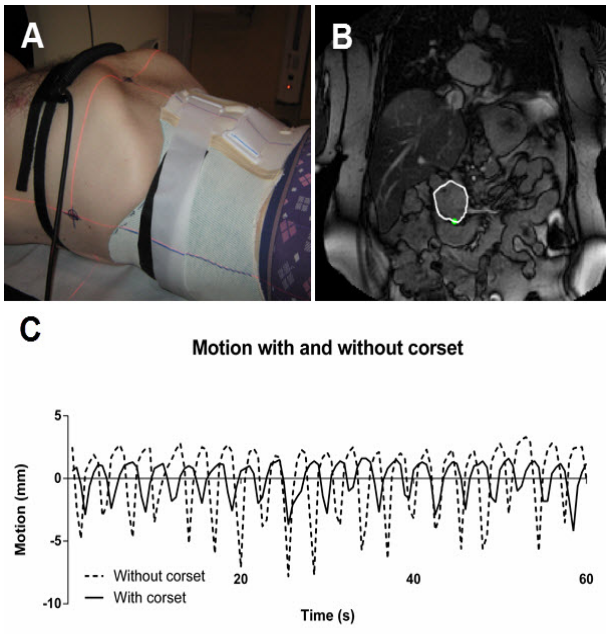

Figure 1. A: Custom-made abdominal corset and CT simulation position. B: Coronal cine MRI. The tumor is circled in white and the dot is followed in time. C: Craniocaudal pancreatic tumor motion with (solid line) and without (dotted line) corset.

Table 1: Motion characteristics

	With corset	Without corset	Motion reduction
Craniocaudal (sagittal)			
100% motion (mm)	7.2 (4.1-12.1)	11.3 (7.5-22.1)	4.1
95% motion (mm)	5.6 (3.4-9.8)	8.9 (6.4-14.7)	3.3
Craniocaudal (coronal)			
100% motion (mm)	7.3 (4.4-13.4)	11.3 (6.6-19.6)	4.0
95% motion (mm)	5.8 (3.8-10.8)	9.1 (5.5-14.6)	3.3
Anteroposterior (sagittal)			
100% motion (mm)	3.3 (2.0-4.6)	3.3 (2.6-4.6)	0.0
95% motion (mm)	2.9 (1.8-4.1)	2.9 (2.3-4.1)	0.0
Lateral (coronal)			
100% motion (mm)	2.9 (1.1-5.0)	3.3 (1.9-7.5)	0.4
95% motion (mm)	2.4 (0.9-4.2)	2.9 (1.6-6.2)	0.5

All values are average values (range)

Conclusions: Substantial pancreatic tumor motion decrease was observed with the use of a custom abdominal corset. As a result, treatment margin reduction is possible for stereotactic radiotherapy in free breathing conditions with maintained patient comfort. This in turn offers opportunities for dose escalation without increasing toxicity.

PO-0933

Calypso-guided MLC tracking on a TrueBeam accelerator

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Purpose/Objective: MLC tracking is a promising method for real-time target motion compensation by continuous adaptation of the MLC aperture to a moving target. A number of studies with proto-type MLC tracking systems have demonstrated the ability to mitigate motion-induced dose errors, and a non-commercial system is currently used in a clinical study of prostate cancer. However, to get MLC tracking into routine clinical practice at a larger scale a more integrated system is needed. This study provides the first characterization of the prototype MLC tracking system included in the research part of the Varian TrueBeam 2.0 accelerator.

Materials and Methods: Several experiments were performed to characterize the performance of Calypso-guided MLC tracking on a TrueBeam linear accelerator. The MLC tracking system latency was determined as the time lag between sinusoidal target motion and the center of a circular beam as recorded by continuous MV portal imaging during MLC tracking with prediction turned off. Normally, the jaws also follow the target just outside the MLC aperture. The tracking latency of the backup jaws was determined similarly in portal images by tracking a rectangular field formed by the jaws alone. The geometric tracking accuracy was determined as the 2D distance in portal images between a target following eight representative trajectories (prostate and lung) and the